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PAPERS READ BEFORE THE ACADEMY,

SESSION OF 1867-68.

XIX.—ON THE PHYSIOLOGY OF PROTRUSION OF THE TONGUE, AND ITS
DEVIATION TO THE AFFECTED SIDE IN UNILATERAL PARALYSIS. BY
THOMAS HAYDEN, M.D., M.R.I.A.

[Read June 11, 1866.*]

IN the communication which I have the honour of submitting to the Academy I propose to discuss the physiology of protrusion of the tongue, and to endeavour to explain the apparent anomaly by which, in unilateral paralysis of that organ, as exemplified in hemiplegia, it deviates in protrusion to the paralyzed side, whereas the features, as is well known, move to the opposite or unaffected side, as does likewise the tongue itself in all its movements save that of protrusion.

In order to render intelligible what follows, it will be necessary to start with a few general propositions in reference to the action of voluntary muscles.

Muscular contraction consists essentially in intrinsic molecular approximation, by which the constituent particles of the muscle, its sarcois elements, are brought into closer mutual proximity, and the extremities of the muscle itself are drawn towards one another.

The range of contraction of a muscle is directly as the length of its fibres, irrespectively of tendon and all other extrinsic substances, and has been variously estimated at one-half to two-thirds of their length.

The force of the contraction of a muscle is as the number and diameter of its fibres, irrespectively of their length; and its effect depends mainly upon the angle at which it is inserted into the osseous lever; the order of lever used; and the point of attachment.

In no instance can a muscle in contraction carry its moveable, beyond its fixed point of attachment.

A muscle acting upon a lever at an acute angle, and moving it in the direction of its axis, may, however, carry the proximal extremity of the lever far beyond its own fixed point of attachment, the distance being regulated by the length of the lever, and the length of the fibres of the muscle (see diagram No. 1, Pl. XIII.).

Two levers so acted upon by two coequal forces, and moving at an acute angle, say of 45° , would have a tendency to intersect at their point of mutual contract; if inflexible, and offering equal resistance, they would both be arrested at this point; but if flexible, of equal power of resistance, and propelled by equal forces, they would advance,

* This paper was held over for the "Transactions," but the author not wishing to leave it any longer unpublished, it is printed here, though not properly belonging to the Session of 1867-68.

not in the axis of either, but in a line bisecting the angle formed by their prolonged axes (see diagram No. 2, Pl. XIII.).

If, however, the propelling forces be unequal, both levers will deviate to the side of that which is the weaker; and if either force be entirely annihilated, then the two levers, though with diminished impetus, will advance in the prolonged axis of the lever of the unaffected side (see diagram No. 3, Pl. XIII.).

The tongue, as a muscular organ, consists of intrinsic and extrinsic muscles. It would be easy to show, were that necessary to my present purpose, that the principal of the intrinsic muscles—namely, the *lingualis* of Douglas, is connected with the os hyoides. The function of these muscles is to impart to the tongue intrinsic motions, by which its shape and consistence are altered; whilst that of the extrinsic muscles is to communicate to it movements of place and direction, to modify its figure; and likewise of necessity its density.

The extrinsic muscles of the tongue are the *stylo-glossus*, the *hyo-glossus*, the *palato-glossus*, and the *genio-hyo-glossus*; these muscles are connected, as their names imply, with the styloid process of the temporal bone; the os hyoides; the soft palate, and the chin, or body of the inferior maxilla, respectively. The *stylo-glossus* retracts the tongue, draws it towards the corresponding side, deflects its apex to the same side, and acting in conjunction with the corresponding muscle of the opposite side, may expand it transversely, and raise it to the palate. The *hyo-glossi* retract the protruded tongue whilst contracting it in its transverse diameter, and by depressing its edges they may render its upper surface convex. The *palato-glossus* may raise the edge of the tongue, and, with the muscle of the opposite side, render its superior surface transversely concave.

The action of the *genio-hyo-glossi* is that to which I would invite the special attention of the Academy. These muscles arise from the superior genial eminence of the inferior maxilla, by a common tuft-like tendon, from which the fibres of each muscle expand like the rays of a fan; the posterior fibres pass backwards and downwards, to be inserted into the body of the os hyoides; all the other fibres pass through the substance of the tongue, at each side of the middle line, from its inferior, towards its superior surface, with various, but successively-diminishing degrees of obliquity from behind forwards; the anterior fibres, after transversing the substance of the tongue in the direction upwards and backwards for some distance, are curved forward; whilst those immediately in front, which reach the apex of the tongue, are likewise curved slightly downwards in the terminal portion of their course (see diagram No. 4, Pl. XIII.).

The absolute direction of the fibres, from origin to insertion, will be found to vary according to the position of the tongue. When that organ is entirely confined within the intra-dental portion of the mouth, all the fibres of the *genio-hyo-glossus*, with the exception of the extreme anterior, pass backwards and downwards; but when the tongue is protruded, or forcibly drawn forwards out of the mouth, the fibres

of the anterior half of the muscle pass upwards, and the greater portion of them likewise forwards.

I am not now concerned with the so-called genio-pharyngeus, which has been described as an offset from the genio-hyo-glossus, passing from the edge of the tongue to the mylo-hyoid ridge, and constituting the glossal attachment of the superior constrictor of the pharynx.

If the relative disposition of the inner or opposed surfaces of the genio-hyo-glossi muscles of opposite sides be carefully examined, it will be found that they are not parallel, as usually described in works on anatomy, but disposed, relatively to one another, at an acute angle, salient forwards.

This angle is maintained, and the intervening space is filled up, by a soft, granular, adipose substance, which exists in greatest quantity behind, in the vicinity of the os hyoides, where the interspace between the muscles is widest. To this substance Haller attributes the function of lubricating the muscular fibres, and thus obviating the effects of mutual friction; but this purpose we know to be served by a fine fluid, which during life, and at the temperature of the body, is probably in a state of halitus; besides, in other muscles and muscular organs, for example the heart, where action is not less vigorous, fat does not exist in the healthy state.

The principal, if not the only purpose of the lingual fat or smegma seems to be, to divaricate the genio-hyo-glossi muscles in conformity with the figure of the tongue, and thereby confer upon that organ greater precision and concentration of force in its forward movements. Haller, in his treatise *De Fabrica et usu Linguae*, whilst attributing to this fat the purpose already mentioned, admits that it exists in greatest quantity near the os hyoides, where obviously muscular movement is least active, and where, consequently, the function he assigns to it would be least required: he says—"Interstitia enim hujusmodi fibrarum ad basin linguae, quâ ossi hyoidi adhæret, præcipue copiosa pinguedine replentur."*

Malpighi,† whilst admitting that the principal situation of the lingual adeps is at the base of the organ, assigns to it no particular use.

As regards the agency by which the tongue is protruded from the mouth, all anatomists are agreed in regarding the genio-hyo-glossi muscles as the sole active agents in that movement. Haller‡ says, "valet hic musculus (viz. genio-glossus) linguam in anteriora trahere, et simul ex ore protrahere."

This, it will be perceived, is a very vague and indefinite account of the action of these muscles, and still less satisfactory is it, as will appear in the sequel, as an explanation of the mode in which protrusion of the tongue is accomplished. Yet, in no work preceding that of Haller, nor in any written since his time that I have had an oppor-

* Haller "*De fabrica et usu Linguae*," c. xxxviii.

† Marcelli Malpighi *exercitas epistolica de lingua ad Alphonsum Borellium* 1664, p. 38.

‡ "*Opus citat.*," c. lxxviii.

tunity of consulting, is a more full or definite exposition of this subject to be found than is contained in the short passage just quoted.

That the ordinary rules which govern muscular action are not applicable to the genio-hyo-glossi muscles, as protrusors of the tongue, will appear from two considerations :—

1st. There is no example in the body, unless that furnished by these muscles can be admitted as such, of a muscle carrying its moveable point of attachment beyond its fixed point, by its own contraction.

2nd. There is absolutely no example in the body, except in the instance of the tongue, of a symmetrical organ, paralysed on one side, and moving, by contraction of its muscles, *towards* the side of paralysis.

The point of origin of the genio-hyo-glossus being the superior genial eminence, the course of all its fibres, from origin to insertion, when the tongue is lodged within the mouth, must be more or less directly backwards, owing to the prominence of the chin (see diagram No. 4). The initiatory stage of the advancement of the tongue, therefore, involves no difficulty of comprehension; it is effected in accordance with the law of muscular dynamics, by which the extremities of a muscle in contraction tend to approach one another.

The progress of the tongue beyond the line of the teeth cannot be explained under this law, for it involves the transgression of the fixed point of attachment of the muscles engaged, by their moveable points, and in a ratio proportionate to its advancement; but without infringing this law, the fibres of a muscle inserted at an acute angle into a distant point of a lever may advance that lever in the direction of its axis, or at an angle with it, and in proportion to their length, as has been already shown, and will be understood by reference to diagram No. 1. In this law, I conceive, lies the explanation of the protrusion of the tongue under the action of the genio-hyo-glossi muscles, to which I now invite the attention of the Academy.

It has been already shown that these muscles, radiating from a common point of origin on the posterior surface of the body of the inferior maxilla, are inserted into the os hyoides and inferior surface of the tongue along its middle line from base to apex, penetrating its substance even to its dorsum. For the present I leave out of consideration the angularity of the planes of the two muscles, as being unnecessary to the subject under discussion, namely, the protrusion of the tongue, and in no way qualifying my argument. In the initiatory stage of protrusion the fibres of the two muscles, having all a direction more or less backwards (see diagram No. 4), co-operate to pull the tongue out of the mouth; the dorsum is depressed and rendered flat; the tongue becomes rigid and straight; the os hyoides is raised towards the mouth, and the tip advances beyond the line of the teeth. In the further progress of the tongue the anterior fibres cease to co-operate, maintaining only a state of tonic contraction, and regulating the direction of the apex under the guidance of volition. In proportion as the tongue advances a greater number of the fasciculi of

the muscles become inert as regards protrusion, till the final stage is arrived at, which is accomplished by the posterior fibres only, and therefore with greatly diminished force. Retraction of the tongue is now effected by all the fibres of these muscles, whose point of insertion is in front of their point of origin, assisted by the special retractors, namely, the hyo, and stylo-glossi (see diagram No. 4). During the progress of the tongue forwards the organ is converted into a solid and rigid lever by the antagonistic action of the stylo-glossi, palato-glossi, and hyo-glossi muscles, the two former of which tend to elevate, and the latter to depress it; whilst the stylo-glossi, by their course along the margins of the tongue to its apex, and acting in equilibrium, render it straight and rigid in its entire length. In this explanation it is impossible to ignore the wonderful selective power which the will possesses, of directing upon special groups of muscles, upon individual muscles, and even upon particular parts of the same muscle, the stimulus of contraction, and in greater or less degree according to circumstances.

Owing to the fan-like arrangement of the fibres of the genio-hyo-glossi, the anterior fasciculi of the muscles must successively pass out of action as protrusors, according as their points of insertion are carried in front of the teeth by the advancing tongue; hence the progress of the tongue forwards must be effected with progressively diminishing power (see diagram No. 4). I have verified this observation in my own person by the following simple experiment:—

A light wooden cylinder was introduced into my mouth, within the range of my teeth; the opposite end of the cylinder rested on a balance; the balance was now weighted, and I found that by pressing the point of my tongue against the end of the cylinder in my mouth, with all the force I was capable of exercising, I could lift a weight of 4lbs. When the tongue was advanced a quarter of an inch in front of the teeth, I could lift $2\frac{1}{2}$ lbs., and when three-quarters of an inch only 2lbs.

No doubt this result may be in some measure explained in another way. It has been shown by Schwann that muscles contract with maximum power in the acme of extension, and with a force diminishing in a progressive ratio as contraction proceeds; but manifestly so great a difference in the lifting force of the tongue, as that between 4lbs. and $2\frac{1}{2}$ lbs., cannot be accounted for in this way. In other words, a loss of nearly one-half the protrusive force of the tongue could not be occasioned by a contraction of a quarter of an inch in the posterior fibres of its protrusor muscles.

In the exhaustive treatise of Bourguery and Jacob,* I find the following statement:—"As to the comparison of the two genio-glossi muscles, since they are united along the middle plane, it will be difficult to apprehend a very perceptible difference between their isolated and simultaneous contraction."

* *Traité Complet de l'Anatomie de l'Homme*, vol. ii., page 53.

If the muscles were united along the middle plane as described, or if they were parallel by their opposed surfaces, then, no doubt, they would simply reinforce one another; and, considering the direction in which their force is applied, it would be difficult to conceive how, under these circumstances, they could serve as reciprocal antagonists, as is the case with all other duplicate muscles disposed at opposite sides of the median line.

But anatomy shows that they are not parallel; they are disposed at a very acute angle, salient forwards, and are separated behind by a mass of soft adipose tissue as already described.

The triangular interval between the muscles, as likewise the adipose substance which occupies it, will be readily perceived on making a horizontal section of the boiled tongue of the sheep, or other mammal, near its inferior surface, and through its entire length.

Pathology shows no less conclusively a marked difference as between the isolated and combined action of the Genio-hyo-glossi muscles, and the existence of a very decided antagonism between them.

In complete hemiplegia involving the face and tongue, the features, as is well known, are drawn towards the unaffected side, whilst the tongue in protrusion deviates to the side of paralysis; this shows, as regards the tongue, an antagonism between its protrusor muscles, but of a very peculiar and exceptional character, and at the same time seems to be in contravention of the law, that muscles, when paralyzed, are overpowered by their antagonists, and drawn in the direction of the fixed attachments of the latter. In protrusion of the tongue the muscles engaged are mutually co-operative, and corrective of one another; they act upon the tongue as upon a rigid lever, but acting at an angle, each tends to carry it forwards and to the *opposite* side; acting, however, simultaneously, and with equal force, they correct one another, and carry the tongue directly forwards, that is to say, in a line intermediate between their respective axes (see diagram No. 2).

In the event of one of these two forces being suspended, as occurs in hemiplegia, the opposing force being now the sole agent in protrusion, and free to act without correction, will carry the tongue forwards and to the *opposite* or paralyzed side, that is to say, in the axis of its own proper motion (see diagram No. 3).

In case of partial paralysis of one of the opposing muscles, the tongue, being in some degree governed by the weaker force, will advance in a direction less decidedly lateral, or at an angle with the common axis of motion of the two muscles, determined by their relative contractile force, and directly as the difference in force between them (see diagram No. 3).

Granted that the genio-hyo-glossi muscles are the sole protrusors of the tongue; I submit—

1st. That their action is peculiar in this; that whilst in the first stage of protrusion they act, like other muscles, by traction; in the latter stages they act by propulsion.

2nd. That in propelling the tongue forwards they act upon it as a

lever of the first order, the anterior extremity of which projects from the mouth; the posterior extremity within the mouth being acted upon by the protrusors, and the fulcrum constituted by the palato-glossi muscles (see diagram No. 4).

3rd. The Genio-hyo-glossi muscles are disposed relatively to one another at a very acute angle, salient forwards, and therefore taken separately they act upon the tongue in protrusion, not in the direction of its axis, but at an acute angle with it, carrying it to the opposite side; but acting conjointly, and with equal force, they are mutually corrective of one another, and carry the tongue directly forwards.

And, 4th. As a necessary consequence, when the protrusor muscle of one side is paralyzed, the other, acting without correction, will protrude the tongue towards the side of paralysis.

XX.—CATALOGUE OF 101 DRAWINGS OF ARCHITECTURAL ANTIQUITIES, FROM ORIGINAL SKETCHES, PRESENTED TO THE LIBRARY OF THE ROYAL IRISH ACADEMY. By GEORGE V. DU NOYER, M.R.I.A., &c., District Surveyor, Geological Survey of Ireland, to form Vol. IX. of a similar donation.

[Read November 11, 1867.]

Mellifont Abbey, Co. Louth.

No. 1. View, looking N. N. W., of the choir of the great church. This building has been erroneously regarded by recent writers as "the great church of Mellifont Abbey," and surprise is expressed that it could have contained the eleven high altars recorded to have been within it. To any careful observer, it is evident that the building in question is merely a *choir* of what may have been a church of noble proportions, possibly of forty feet in width, and twice or more that in length.

No. 2. Plan of the choir of the great church. From this it is evident that the so-called "doorway" is in reality the choir arch; its recessed pilasters being all on the interior face of the wall, the external portion being flat—a style of architecture unknown in the construction of church doorways.

The remarkable narrowness of this choir arch is no doubt the result of careful design, with a view to render the choir as sacred as possible, and allow but a glimpse from the body of the church into that more sacred portion of it, which glittered with stained glass, gold, and fresco painting.*

No. 3. Choir arch.

No. 4. Window in south wall of the choir.

No. 5. Quaint figure of an animal carved in high relief on the key-stone of the outer arch. East window, from the same.

No. 6. Pilasters, N. W. angle of the choir.

* See "Wilde's Beauties of the Boyne and Blackwater." 2nd edition.